GENERAL APTITUDE

Q. No. 1 – 5 Carry One Mark Each

1. Choose the word most similar in meaning to the given word: Educe

(A) Exert (B) Educate (C) Extract (D) Extend

Answer: (C)

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2. If $\log_x (5/7) = -1/3$, then the value of x is

(A) 343/125 (B) 12/343 (C) –25/49 (D) –49/25

Answer: (A)

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3. Operators $\square, \Diamond$ and $\rightarrow$ are defined by: $a \square b = \frac{a-b}{a+b}; a \Diamond b = \frac{a+b}{a-b}; a \rightarrow b = ab.$

Find the value $(66 \square 6) \rightarrow (66 \Diamond 6)$.

(A) –2 (B) –1 (C) 1 (D) 2

Answer: (C)

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4. Choose the most appropriate word from the options given below to complete the following sentence.

The principal presented the chief guest with a _____, as token of appreciation.

(A) momento (B) memento (C) momentum (D) moment

Answer: (B)

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5. Choose the appropriate word/phrase, out of the four options given below, to complete the following sentence:

Frogs _____.

(A) Croak (B) Roar (C) Hiss (D) Patter

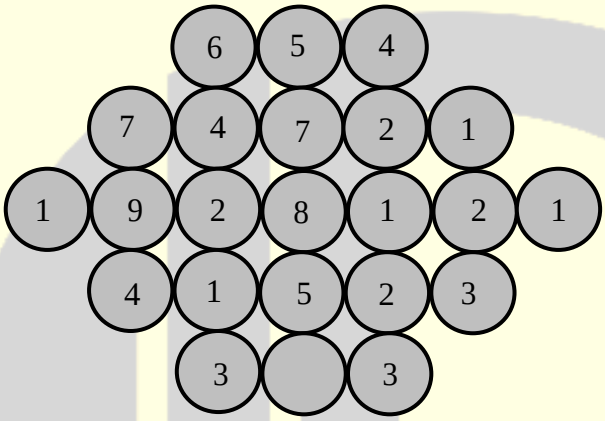
Answer: (A)

6. A cube of side 3 units is formed using a set of smaller cubes of side 1 unit. Find the proportion of the number of faces of the smaller cubes visible to those which are NOT visible.

(A) 1 : 4 (B) 1 : 3 (C) 1 : 2 (D) 2 : 3

Answer: (C)

7. Fill in the missing value



Answer: (3)

8. Humpty Dumpty sits on a wall every day while having lunch. The wall sometimes breaks. A person sitting on the wall falls if the wall breaks.

Which one of the statements below is logically valid and can be inferred from the above sentences?

(A) Humpty Dumpty always falls having lunch

(B) Humpty Dumpty does not fall sometimes while having lunch

(C) Humpty Dumpty never falls during dinner

(D) When Humpty Dumpty does not sit on the wall, the wall does not break

Answer: (B)

9. The following question presents a sentence, part of which is underlined. Beneath the sentence you find four ways of phrasing the underlined part. Following the requirements of the standard written English, select the answer that produces the most effective sentence.

Tuberculosis, together with its effects, ranks one of the leading causes of death in India.

(A) ranks as one of the leading causes of death

(B) rank as one of the leading causes of death

(C) has the rank of one of the leading causes of death

(D) are one of the leading causes of death

Answer: (A)

10. Read the following paragraph and choose the correct statement.

Climate change has reduced human security and threatened human well being. An ignored reality of human progress is that human security largely depends upon environmental security. But on the contrary, human progress seems contradictory to environmental security. To keep up both at the required level is a challenge to be addressed by one and all. One of the ways to curb the climate change may be suitable scientific innovations, while the other may be the Gandhian perspective on small scale progress with focus on sustainability.

(A) Human progress and security are positively associated with environmental security.

(B) Human progress is contradictory to environmental security.

(C) Human security is contradictory to environmental security.

(D) Human progress depends upon environmental security.

Answer: (D)

CHEMICAL ENGINEERING

Q.No. 1-25 Carry One Mark Each

1. Benzene is removed from air by absorbing it in a non-volatile wash-oil at 100kPa in a counter-current gas absorber. Gas flow rate is 100 mol/min, which includes 2 mol/min of benzene. The flow rate of wash-oil is 50 mol/min. Vapour pressure of benzene at the column conditions is 50 kPa. Benzene forms an ideal solution with the wash-oil and the column is operating at steady state. Gas phase can be assumed to follow ideal gas law. Neglect the change in molar flow rates of liquid and gas phases inside the column.

For this process, the value of the absorption factor (upto two decimal places) is _____.

Answer: (1.02)

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2. The following set of three vectors

$$\begin{pmatrix}1\\2\\1\end{pmatrix}, \begin{pmatrix}x\\6\\x\end{pmatrix} \text{ and } \begin{pmatrix}3\\4\\2\end{pmatrix}$$

is linearly dependent when x is equal to

(A) 0 (B) 1 (C) 2 (D) 3

Answer: (D)

---

3. For which reaction order, the half-life of the reactant is half of the full lifetime (time for 100% conversion) of the reactant?

(A) Zero order (B) Half order (C) First order (D) Second order

Answer: (A)

---

4. Match the output signals as obtained from four measuring devices in response to a unit step change in the input signal.

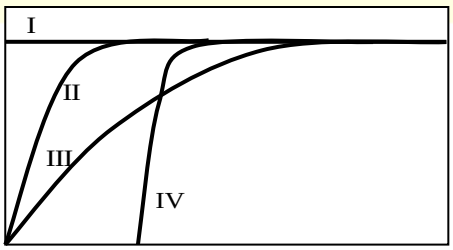
Output signal time:

P: Gas chromatograph, with a long capillary tube

Q: Venturi tube

R: Thermocouple with first order dynamics

S: Pressure transducer with second order dynamics



(A) P-IV, Q-III, R-II, S-I (B) P-III, Q-I, R-II, S-IV

(C) P-IV, Q-I, R-II, S-III (D) P-II, Q-IV, R-III, S-I

Answer: (C)

5. Match the chemicals written on the left with the raw materials required to produce them mentioned on the right.

(I) Single Superphosphate (SSP)	(P) Rock phosphate + Sulfuric Acid + Ammonia
(II) Triple Superphosphate (TSP)	(Q) Brine
(III) Diammonium phosphate (DAP)	(R) Rock Phosphate + Sulfuric Acid
(IV) Caustic soda	(S) Rock phosphate + phosphoric Acid

(A) $I-Q,\ II-R,\ III-S,\ IV-P$ (B) $I-S,\ II-P,\ III-Q,\ IV-R$

(C) $I-R,\ II-S,\ III-P,\ IV-Q$ (D) $I-S,\ II-R,\ III-P,\ IV-Q$

Answer: (C)

6. For the matrix $\begin{pmatrix} 4 & 3 \\ 3 & 4 \end{pmatrix}$, if $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$ is an eigenvector, the corresponding eigenvalue is _____.

Answer: (7)

7. The transfer function for the disturbance response in an open-loop process is given by $G_d^{open}(s)$. The corresponding transfer function for the disturbance response in closed-loop feedback control system with proportional controller is given by $G_d^{closed}(s)$. Select the option that is always correct.

$\{O[G(S)]$ represents order of transfer function $G(s)\}$:

(A) $O\left|G_d^{open}(s)\right| = O\left|G_d^{closed}(s)\right|$ (B) $O\left|G_d^{open}(s)\right| \neq O\left|G_d^{closed}(s)\right|$

(C) $O\left|G_d^{open}(s)\right| \geq O\left|G_d^{closed}(s)\right|$ (D) $O\left|G_d^{open}(s)\right| \leq O\left|G_d^{closed}(s)\right|$

Answer: (A)

8. If v, u, s and g represent respectively the molar volume, molar internal energy, molar entropy and molar Gibbs free energy, then match the entries in the left and right columns below and choose the correct option.

(P) $-(\partial u/\partial v)_s$	(I) Temperature
(Q) $(\partial g/\partial P)_T$	(II) Pressure
(R) $-(\partial g/\partial T)_P$	(III) v
(S) $(\partial u/\partial s)_V$	(IV) s

(A) P – II, Q – III, R – IV, S – I (B) P – II, Q – IV, R – III, S – I

(C) P – I, Q – IV, R – II, S – III (D) P – III, Q – II, R – IV, S – I

Answer: (A)

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9. Two different liquids are flowing through different pipes of the same diameter. In the first pipe, the flow is laminar with centerline velocity, $V_{max.1}$, Whereas in the second pipe, the flow is turbulent. For turbulent flow, the average velocity is 0.82 times the centerline velocity, $V_{max.2}$. For equal volumetric flow rates in both the pipes, the ratio $V_{max.1}/V_{max.2}$ (up to two decimal places) is _____.

Answer: (1.64)

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10. Consider linear ordinary differential equation $\frac{dy}{dx}+p(x)y=r(x)$. Functions $p(x)$ and $r(x)$ are defined and have a continuous first derivative. The integrating factor of this equation is non-zero. Multiplying this equation by its integrating factor converts this into a:

(A) Homogeneous differential equation (B) Non-linear differential equation

(C) Second order differential equation (D) Exact differential equation

Answer: (D)

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11. A spherical naphthalene ball of 2mm diameter is subliming very slowly in stagnant air at 25°C. The change in the size of the ball during the sublimation can be neglected. The diffusivity of naphthalene in air at 25°C is 1.1×10^{-6} m^2/s.

The value of mass transfer coefficient is B × 10^{-3} m/s, where B (up to one decimal place) is _____.

Answer: (1.1)

12. An irreversible, homogeneous reaction $A \rightarrow$ products, has the rate expression:

$\text{Rate} = \dfrac{2C_A^2 + 0.1C_A}{1+50C_A}$, where C_A is the concentration of A.

C_A varies in the range 0.5 – 50 mol/m^3.

For very high concentration of A, the reaction order tends to:

(A) 0 (B) 1 (C) 1.5 (D) 2

Answer: (B)

---

13. A scalar function in the xy-plane is given by $\phi(x,y) = x^2 + y^2$. if $\hat{i}$ amd $\hat{j}$ are unit vectors in the x and y directions, the direction of maximum increase in the value of ϕ at (1,1) is along:

(A) $-2\hat{i}+2\hat{j}$ (B) $2\hat{i}+2\hat{j}$ (C) $-2\hat{i}-2\hat{j}$ (D) $2\hat{i}-2\hat{j}$

Answer: (B)

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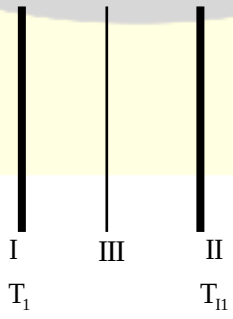
14. For a gas phase cracking reaction $A \rightarrow B + C$ at 300^{O}C, the Gibbs free energy of the reaction at this temperature is $\Delta G^O = -2750 J/mol$. The pressure is 1 bar and the gas phase can be assumed to be ideal. The universal gas constant R = 8.314J/mol. K. The fractional molar conversion of A at equilibrium is:

(A) 0.44 (B) 0.50 (C) 0.64 (D) 0.80

Answer: (D)

---

15. Two infinitely large parallel plates (I and II) are held at temperatures T_I and T_{II} $(T_1 > T_{II})$ respectively, and placed at a distance 2d apart in vacuum. An infinitely large flat radiation shield (III) is placed in parallel in between I and II. The emissivities of all the plates are equal. The ratio of the steady state radiative heat fluxes with and without the shield is:



(A) 0.5 (B) 0.75 (C) 0.25 (D) 0

Answer: (A)

16. A cylindrical packed bed of height 1 m is filled with equal sized spherical particles. The particles are nonporous and have a density of 1500 kg/m^3. The void fraction of the bed is 0.45. The bed is fluidized using air (density 1kg/m^3). If the acceleration due to gravity is 9.8m/s^2, the pressure drop (in pa) across the bed at incipient fluidization (up to one decimal place) is _____.

Answer: (8079.61)

---

17. For a pure liquid, the rate of change of vapour pressure with temperature is 0.1 bar/K in the temperature range of 300 to 350 K. if the boiling point of the liquid at 2 bar is 320 K, the temperature (in K) at which it will boil at 1 bar (up to one decimal place) is _____.

Answer: (310)

---

18. For uniform laminar flow over a flat plate, the thickness of the boundary layer, δ, at a distance x from the leading edge of the plate follows the relation:

(A) $\delta(x) \alpha\, x^{-1}$ (B) $\delta(x) \alpha\, x$ (C) $\delta(x) \alpha\, x^{1/2}$ (D) $\delta(x) \alpha\, x^{-1/2}$

Answer: (C)

---

19. Match the polymer mentioned on the left with the catalyst used for its manufacture given on the right.

(I)	Low density Polyethylene	(P)	Ziegler-Natta catalyst
(II)	High density Polyethylene	(Q)	Traces of Oxygen
(III)	Polyethylene Terephthalate	(R)	Butyl Lithium
(IV)	Polyvinyl Chloride	(S)	Antimony

(A) I – Q, II – R, III – S, IV – P (B) I – S, II – P, III – Q, IV – R

(C) I – Q, II – P, III – S, IV – R (D) I – S, II – R, III – P, IV – Q

Answer: (C)

20. Three identical closed systems of a pure gas are taken from an initial temperature and pressure (T_L, P_1) to a final state (T_2, P_2), each by a different path. Which of the following is always true for the three systems? (Δ represents the change between the initial and final states: U, S, G, Q and W are internal energy, entropy, Gibbs free energy, heat added and work done, respectively.)

(A) $\Delta U, \Delta S, Q$ are same (B) $W, \Delta U, \Delta G$ are same

(C) $\Delta S, W, Q$ are same (D) $\Delta G, \Delta U, \Delta S$ are same

Answer: (D)

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21. Identify the WRONG statement amongst the following:

(A) Steam distillation is used for mixtures that re immiscible with water.

(B) Vacuum distillation is used for mixtures that are miscible with water.

(C) Steam distillation is used for mixtures that are miscible with water.

(D) Vacuum distillation columns have larger diameters as compared to atmospheric columns for the same throughout.

Answer: (C)

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22. For a binary mixture of components A and B, N_A and N_B denote the total molar fluxes of components A and B, respectively. J_A and J_B are the corresponding molar diffusive fluxes. Which of the following is true for equimolar counter-diffusion in the binary mixture?

(A) $N_A + N_B = 0$ and $J_A + J_B \neq 0$ (B) $N_A + N_B \neq 0$ and $J_A + J_B = 0$

(C) $N_A + N_B \neq 0$ and $J_A + J_B \neq 0$ (D) $N_A + N_B = 0$ and $J_A + J_B = 0$

Answer: (A)

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23. A complex-valued function, *f*(*z*), given below is analytic domain D:

$$f(z) = u(x,y) + iv(x,y) \quad z = x + fy$$

Which of the following is NOT correct?

(A) $\frac{df}{dz} = \frac{\partial v}{\partial y} + i\frac{\partial u}{\partial y}$

(B) $\frac{df}{dz} = \frac{\partial u}{\partial x} + i\frac{\partial v}{\partial x}$

(C) $\frac{df}{dz} = \frac{\partial v}{\partial y} - i\frac{\partial u}{\partial y}$

(D) $\frac{df}{dz} = \frac{\partial v}{\partial y} + i\frac{\partial v}{\partial x}$

Answer: (A)

---

24. Which of the following can change if only the catalyst is changed for a reaction system?

(A) Enthalpy of reaction

(B) Activation energy

(C) Free energy of the reaction

(D) Equilibrium constant

Answer: (B)

---

25. Match the technologies in Group 1 with the entries in Group 2:

Group – 1	Group 2
(P) Urea manufacture	(I) Microencapsulation
(Q) Coal gasification	(II) Ultra-low sulphur diesel
(R) Controlled release of chemicals	(III) Shale oil
(S) Deep hydrodesulphurization	(IV) Prilling tower
	(V) Gas hydrates
	(VI) Gas – solid non-catalytic reaction

(A) P – I, Q – V, R – II, S – VI

(B) P – IV, Q – VI, R – I, S – II

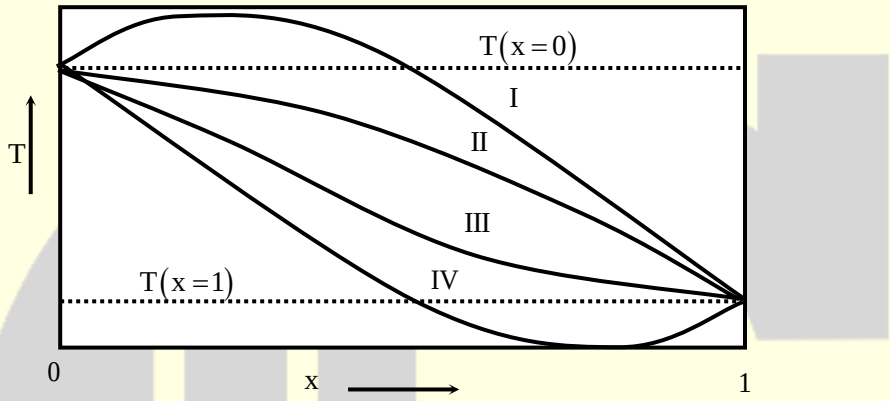
(C) P – IV, Q – I, R – III, S – II

(D) P – V, Q – VI, R – IV, S – II

Answer: (B)

Q.No. 26 – 55 Carry Two Marks Each

26. Consider a solid block of unit thickness for which the thermal conductivity decreases with an increase in temperature. The opposite faces of the block are maintained at constant but different temperatures: T(x = 0) > T(x = 1). Heat transfer is by steady state conduction in x-direction only. There is no source or sink of heat inside the block. In the figure below, identify the correct temperature profile in the block.



(A) I (B) II (C) III (D) IV

Answer: (C)

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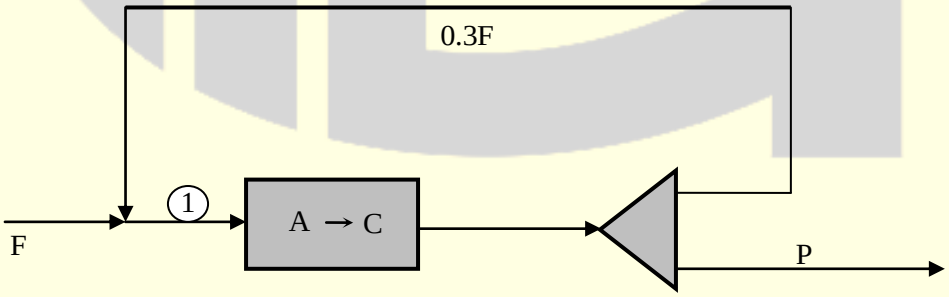
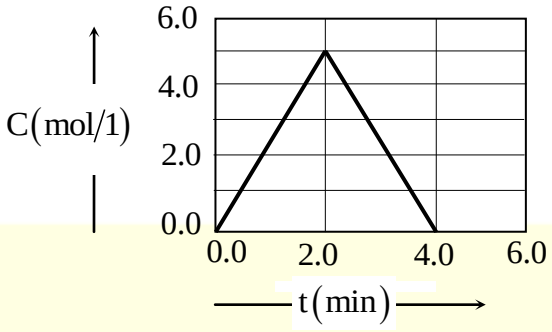
27. The schematic diagram of a steady state process is shown below. The fresh feed (F) to the reactor consists of 96 mol% reactant A and 4 mol% inert I. The stoichiometry of the reaction is $A \rightarrow C$. A part of the reactor effluent is recycled.



The molar flow rate of the recycle stream is 0.3F. The product stream P contains 50 mol% C. The percentage conversion of A in the reactor based on A entering the reactor at point 1 in the figure (up to one decimal place) is _____.

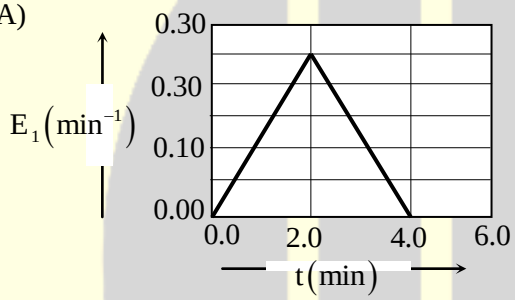
Answer: (59.19)

28. The impulse response to a tracer pulse experiment for a flow reactor is given below:

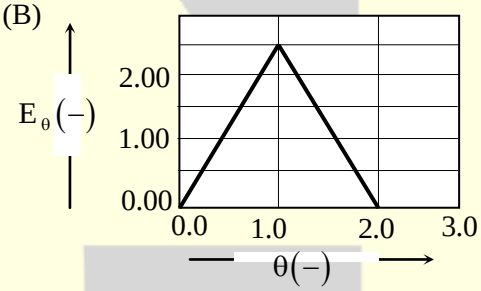


In the above figure, c is the exit tracer concentration. The corresponding E or E_θ (normalized E) curve is correctly represented by which of the following choices? Here, θ is dimensionless time.

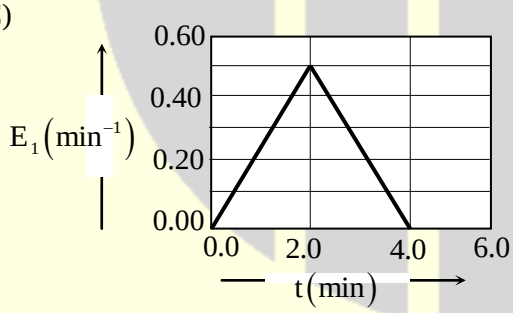
(A)



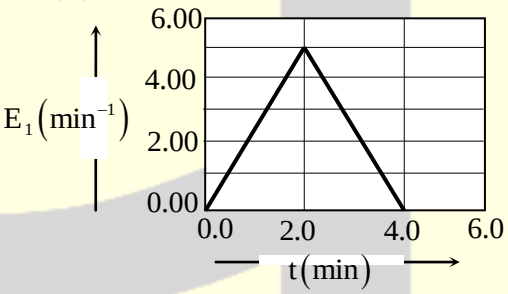
(B)



(C)



(D)



Answer: (C)

29. Consider a steady state mass transfer process between well-mixed liquid and vapour phases of a binary mixture comprising of components A and B. The mole fractions of component A in the bulk liquid (x_A) and bulk vapour (y_A) phases are 0.36 and 0.16, respectively. The mass transfer coefficients for component A in liquid and vapour phases are 0.1 mol/(m^2.s) and 0.05 mol/(m^2.s), respectively. The

vapour-liquid equilibrium can be approximated as $y_A^* = 2x_A$ for x_A less than 0.4. The mole fraction of A in the liquid at the interface (up to two decimal places) is

Answer: (0.08)

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30. A heated solid copper sphere (of surface area A and volume V) is immersed in a large body of cold fluid. Assume the resistance to heat transfer inside the sphere to be negligible and heat transfer coefficient (*h*), density (ρ), heat capacity (C), and thermal conductivity (k) to be constant. Then, at time t, the temperature difference between the sphere and the fluid is proportional to:

(A) $\exp\left[-\frac{h_A}{\rho VC}t\right]$

(B) $\exp\left[-\frac{\rho VC}{hA}t\right]$

(C) $\exp\left[-\frac{4\pi k}{\rho CA}t\right]$

(D) $\exp\left[-\frac{\rho CA}{4\pi k}t\right]$

Answer: (A)

---

31. An ideal gas is initially at a pressure of 0.1 MPa and a total volume of $2m^3$. It is first compressed to 1MPa by a reversible adiabatic process and then cooled at constant pressure to a final volume of $0.2m^3$. The total work done (in kJ) on the gas for the entire process (up to one decimal place) is _____.

Data: R = 8.314 J/molK; heat capacity at constant pressure (C_P) = 2.5R

Answer: (750)

---

32. A centrifugal pump delivers water at the rate of 0.22 m^3/s from a reservoir at ground level to another reservoir at a height H, through a vertical pipe of 0.2m diameter. Both the reservoirs are open to atmosphere. The power input to the pump is 90 kW and it operates with an efficiency of 75%.

Data:

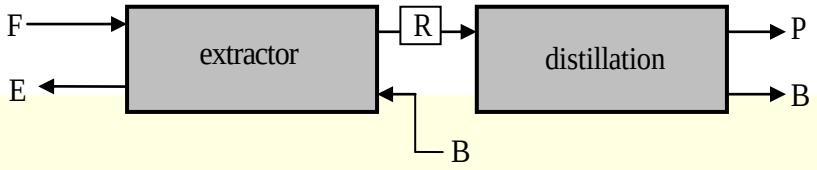
Fanning friction factor for pipe flow is f = 0.004. Neglect other head losses

Take gravitational acceleration, g = 9.8 m/s^2 and density of water is 1000kg/m^3.

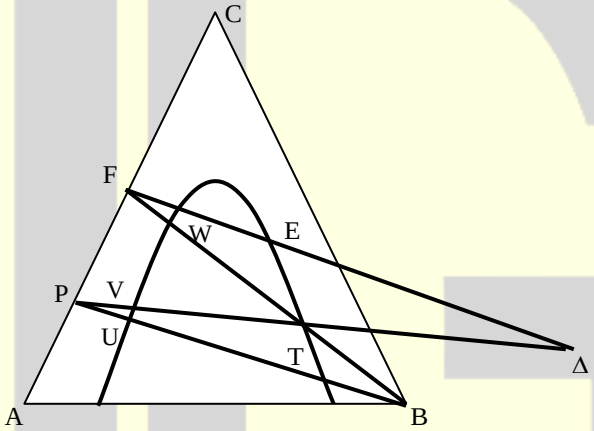
The height H, in meters, to which the water can be delivered (up to one decimal place) is _____.

Answer: (36)

33. A multi-stage, counter-current liquid-liquid extractor is used to separate solute C from a binary mixture (F) of A and C using solvent B. Pure Solvent B is recovered from the raffinate R by distillation, as shown in the schematic diagram below:



Locations of different mixtures for this process are indicated on the triangular diagram below. P is the solvent-free raffinate, E is the extract, F is the feed and Δ is the difference point from which the mass balance lines originate. The line PB interects the binodal curve at U and T. The lines $P\Delta$ and FB intersect the bimodal at V and W respectively.



The raffinate coming out of extractor is represented in the diagram by the point:

(A) T (B) U (C) V (D) W

Answer: (B)

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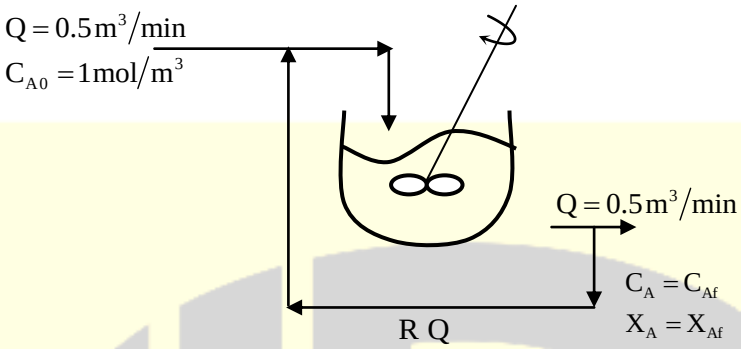
34. The solution of the non-linear equation

$x^3 - x = 0$ is to be obtained using Newton-Raphson method. If the initial guess is x = 0.5, the method converges to which one of the following values:

(A) –1 (B) 0 (C) 1 (D) 2

Answer: (A)

35. An isothermal steady state mixed flow reactor (CSTR) of $1m^3$ volume is used to carry out the first order liquid-phase reaction A $\rightarrow$ products. Fresh feed at a volumetric flow rate of Q containing reactant A at a concentration C_{A0} mixes with the recycle steam at a volumetric flow rate RQ as shown in the figure below.



It is observed that when the recycle ratio R = 0.5, the exit conversion $X_{Af} = 50\%$ When the recycle ratio is increased to R = 2, the new exit conversion (in percent) will be:

(A) 50.0 (B) 54.3 (C) 58.7 (D) 63.2

Answer: (A)

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36. A typical batch filtration cycle consists of filtration followed by washing, One such filtration unit operating at constant pressure difference first filters a slurry during which 5 liters of filtrate is collected in 100 s. This is followed by washing. Which is done for t_w seconds and uses 1 liter of wash water. Assume the following relation to be applicable between the applied pressure drop ΔP, cake thickness L at time t, and volume of liquid V collected in time t.

$$\frac{\Delta P}{L} = k_1 \frac{dv}{dt} \; ; \; L = k_2 V, \text{ if } L \text{ is changing}$$

k_1 and k_2 can be taken to be constant during filtration and washing. The wash time t_w, in seconds (up to one decimal place) is _____

Answer: (40)

---

37. Which one of the following transfer functions, upon a unit step change in disturbance at t = 0, will show a stable time domain response with a negative initial slope (i.e., slope at t = 0):

(A) $G(s)=\frac{1}{s+1}-\frac{2}{s+4}$ (B) $G(s)=\frac{1}{s+1}+\frac{2}{s+4}$

(C) $G(s)=\frac{1}{s+1}+\frac{2}{s-4}$ (D) $G(s)=\frac{1}{s-1}+\frac{2}{s-4}$

Answer: (A)

---

38. Given that molar residual Gibbs free energy, g^R, and molar residual volume V^R, are related as $\frac{g^R}{RT}=\int_0^p\left(\frac{v^R}{RT}\right)dP$, find g^R at $T=27°C$ and $P=0.2\,MPa$. The gas may be assumed to follow the viral equation ofstate, Z=1+BP/RT,where B= $-10^{-4}m^3$/mol at the given conditions (R = 8.314J/mol.K). The value of g^R in J/mol is:

(A) 0.08 (B) –2.4 (C) 20 (D) –20

Answer: (D)

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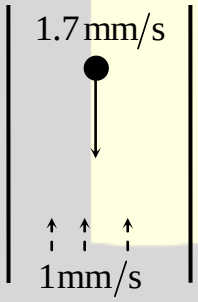
39. A spherical solid particle of 1mm diameter is falling with a downward velocity of 1.7mm/s through a liquid (viscosity 0.04 Pa.s) at a low Reynolds number (Stokes regime).



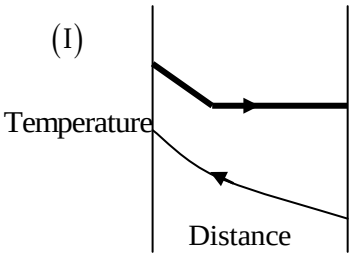
The liquid is flowing upward at a velocity of 1 mm/s. All velocities are with respect to a stationary reference frame. Neglecting the wall effects, the drag force per unit projected area of the particle, in Pa, (up to two decimal places) is _____.

Answer: (1.3)

---

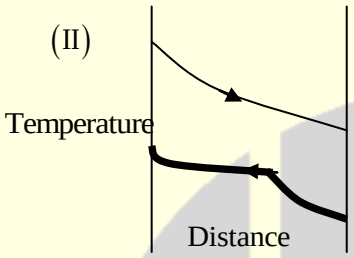
40. In the figure below, the temperature profiles of cold and hot fluids in counter current double pipe heat exchanges (in different mode of operation) are shown on the left. For each case, match the heat exchange process for the fluid represented by the bold curve with the options given on the right.

(I)



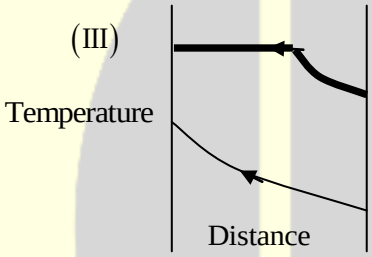
(P) Heating of sub – cooled feed to super heated vapour

(II)



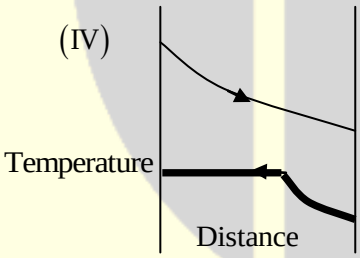
(Q) Condensation of super heated vapour

(III)



(R) Boiling of sub – cooled liquid

(IV)



(S) Condensation of Saturated vapour followed by sub – cooling

(A) I – P, II – Q, III – R, IV – S

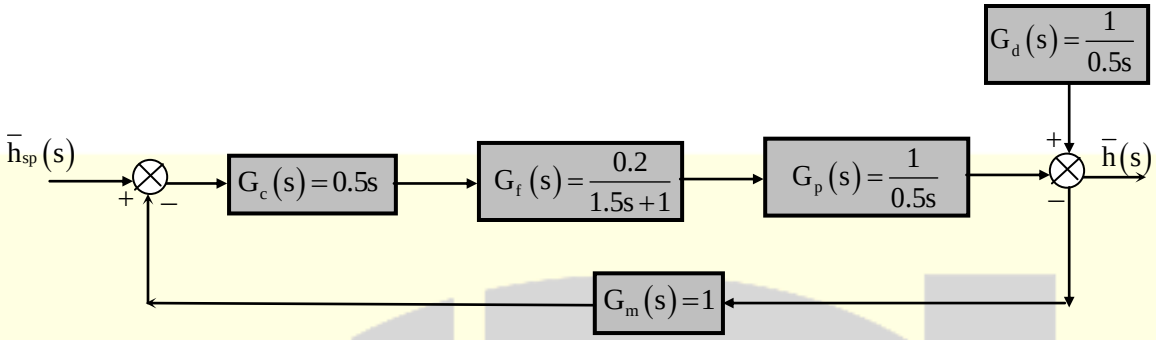
(B) I – P, II – Q, III – S, IV – R

(C) I – Q, II – P, III – S, IV – R

(D) I – Q, II – S, III – P, IV – R

Answer: (C)

41. The block diagram for a process with feedback control for output deviation variable h is shown in the figure below. All transfer functions are given with pre-factor of s in minutes.



A unit step change is made in the set-point at t = 0. The time required for h to reach 50% of its ultimate value, in minutes (up to two decimal places), is: _____.

Answer: (0.8664)

---

42. Adsorption on activated carbon is to be used for reducing phenol concentration in wastewater from 0.04 mol/1 to 0.008mol/1. The adsorption isotherm at the operating temperature can be expressed as $q = 0.025C^{1/3}$; where q is the phenol concentration in solid (mol/g solid) and C is the phenol concentration in water (mol/1). The minimum amount of solid (in grams) required per liter of wastewater (up to one decimal place) is _____

Answer: (6.4)

---

43. Consider a control system with the open loop transfer function given by:

$$G_{OL}(s)=\frac{K_e e^{-0.3c}}{1.5s+1}$$

In the above function, pre-factor of s is in minutes and K_C is the gain of proportional controller.

The frequency for phase margin of 30^O is 40.04rad/min. The value of K_C for a gain margin of 1.7 (up to one decimal place) is _____

Answer: (5.019)

44. For complex variable Z, the value of the contour integral $\frac{1}{2\pi i}\int_c \frac{e^{-2z}}{z(z-3)}dz$ along the clockwise contour C: $|z|=2$ (up to two decimal places) is _____

Answer: (–0.33)

---

45. A proposed chemical plant is estimated to have a fixed capital (FC) of Rs. 24 crores. Assuming other costs to be small, the total investment may be taken to be same as FC. After commissioning (at t = 0 years), the annual profit before tax is Rs.10 crores/year (at the end of each year) and the expected life of the plant is 10 years. The tax rate is 40% per year and a linear depreciation is allowed at 10% per year. The salvage value is zero. If the annual interest rate is 12% the NPV (net present value or worth) of the project in crores of rupees (up to one decimal place) is _____.

Answer: (15.2)

---

46. For fanning friction factor f(for flow in pipes) and drag coefficient C_D(for flow over immersed bodies), which of the following statements are true?

P: faccounts only for the skin friction

Q: C_D accounts only for the form friction

R: C_D accounts for both skin friction and form friction

S: Both f and CD depend on the Reynolds number

T: For laminar flow through a pipe, f doubles on doubling the volumetric flow rate.

(A) R,S,T (B) P,Q,S (C) P,R,S (D) P,Q,S,T

Answer: (C)

---

47. A binary feed consisting of 25 mol% liquid and 75 mol% vapour is separated in a staged distillation column. The mole fraction of the more volatile component in the distillate product is 0.95. The molar flow rate of distillate is 50% of the feed flow rate and McCabe-Thiele method can be used to analyze the column. The q-line intersects the operating line of the enriching section at (0.35,0.5) on the x-y diagram. The slope of the stripping section operating line (up to one decimal place) is _____

Answer: (1.4)

---

48. A catalyst slab of half-thickness L (the width and length of the slab>> L) is used to conduct the first order reaction $A \rightarrow B$. At 450 K, the Thiele modulus for this system is 0.5. The activation energy for the first

order rate constant is 100kJ/mol. The effective diffusivity of the reactant in the slab can be assumed to be independent of temperature, and external mass transfer resistance can be neglected. If the temperature of the reaction is increased to 470 K, then the effectiveness factor at 470 K (up to two decimal place) will be _____. (Value of universal gas constant = 8.314 J/mol/K)

Answer: (1.875)

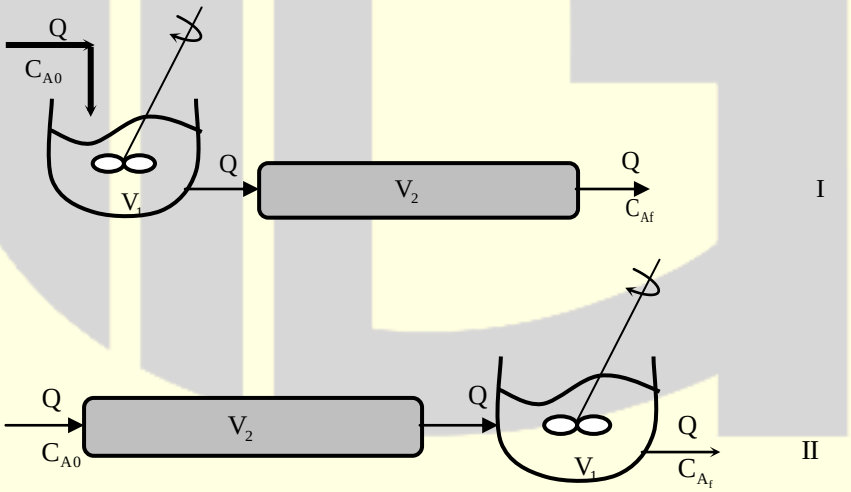
---

49. The diameter of sand particles in a sample range from 50 to 150 microns. The number of particles of diameter x in the sample is proportional to $\frac{1}{50+x}$. The average diameter, in microns, (up to one decimal place) is _____.

Answer: (93.3 to 95.3)

---

50. Consider two steady isothermal flow configuration shown schematically as Case I and Case II below. In case I, a CSTR of volume V_1 is followed by a PFR of volume V_2, while in Case II a PFR of volume V_2 is followed by a CSTR of volume V_1. In each case, a volumetric flow rate Q of liquid reactant is flowing through the two units in series. An irreversible reaction A $\rightarrow$ products (order n) takes place in both cases, with a reactant concentration C_{A0} being fed into the first unit.



Choose the correct option:

(A) $\frac{C^{I}_{A_f}}{C^{II}_{A_f}} > 1$ for $n = 1$

(B) $\frac{C^{I}_{A_f}}{C^{II}_{A_f}} = 1$ for $n = 1$

(C) $\frac{C^{I}_{A_f}}{C^{II}_{A_f}} < 1$ for $n = 1$

(D) $\frac{C^{I}_{A_f}}{C^{II}_{A_f}} = 1$ for $n > 1$

Answer: (B)

51. Select the wrong statement regarding water gas shift converters from the list below.

(A) Inter-stage cooling is provided between the two stages of shift converters.

(B) Usually high temperature shift (HTS) reactor has a iron-based catalyst and low temperature shift (LTS) reactor has a copper-based catalyst.

(C) HTS reactor is followed by LTS reactor.

(D) LTS reactor is followed by HTS reactor.

Answer: (D)

---

52. A vector $u = -2yi + 2xj$, where i and j are unit vector in x and y directions, respectively. Evaluate the line integral

$$I = \oint_c u.dr$$

Where C is a closed loop formed by connecting points (1,1) , (3,1),(3,2) and (1,2) in the order. The value of I is _____.

Answer: (8)

---

53. A binary mixture of components (1) and (2) forms an azeotrope at 130^{O}C and x_1 = 0.3. The liquid phase non-ideality is described by $ln\,\gamma_1 = Ax_2^2$ and $ln\,\gamma_2 = Ax_1^2$, where γ_1, γ_2 are the activity coefficients, and x_1, x_2 are the liquid phase mole fractions. For both components, the fugacity coefficients are 0.9 at the azeotropic composition. Saturated vapor pressures at 130°C are $P_1^{sat} = 70$ bar $P_2^{sat} = 30$ bar.

The total pressure in bars for the above azeotopic system (up to two decimal places) is

Answer: (27.54)

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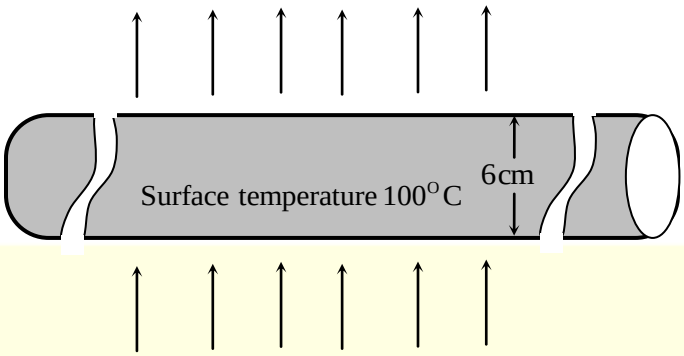
54. Air is flowing at a velocity of 3m/s perpendicular to a long pipe as shown in the figure below. The outer diameter of the pipe is d = 6 cm and temperature at the outside surface of the pipe is maintained at 100^{o}C. The temperature of the air far from the tube is 30^{O}C.

Data for air Kinematic Viscosity, $V = 18\times10^{-6}\ m^2/s$; Thermal conductivity, k = 0.3 W/(m.K)

Using the Nusselt number correlation : $Nu = \frac{hd}{k} = 0.024\times Re^{0.8}$, the rate of heat loss per unit

Length (W/m) from the pipe to air (up to one decimal place) is _____.



Answer: (250.945)

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55. The cost of two independent process variable f_1 and f_2 affects the total cost CT (in lakhs of rupees) of the process as per the following function:

$$C_T = 100f_1 + \frac{1000}{f_1 f_2} + 20f_2^2 + 50$$

The lowest total cost C_T, in lakhs of rupees (up to one decimal place), is _____.

Answer: (572.8)